STUDY GUIDE

ACTIVATED SLUDGE

INTRODUCTION AND ADVANCED

SUBCLASS C

WISCONSIN DEPARTMENT OF NATURAL RESOURCES
BUREAU OF INTEGRATED SCIENCE SERVICES
P. O. BOX 7921
MADISON, WI 53707

JANUARY 1994 EDITION

PREFACE

This operator's study guide represents the results of an ambitious program. Operators of wastewater facilities, regulators, educators and local officials, jointly prepared the objectives and exam questions for this subgrade.

The objectives in this study guide have been organized into modules, and within each module they are grouped by major concepts.

HOW TO USE THESE OBJECTIVES WITH REFERENCES

In preparation for the exams, you should:

1. Read all the objectives that apply to the grade level desired and write down the answers to the objectives that readily come to mind.

2. Use the references at the end of the study guide to look-up answers you don't know. This one set of references covers all of the objectives.

3. Write down the answers found in the references to those objectives you could not answer from memory.

4. Review all answered objectives until you can answer each from memory.

IT IS ADVISABLE THAT YOU ATTEND SOME FORM OF FORMAL TRAINING IN THIS PROCESS BEFORE ATTEMPTING THE CERTIFICATION EXAM.

Choosing A Test Date

Before you choose a test date, consider the training opportunities available in your area. A listing of training opportunities and exam dates can be found in the annual DNR "Certified Operator," or by contacting your DNR District operator certification coordinator.

INTRODUCTION

MODULE A: PRINCIPLE, STRUCTURE AND FUNCTION

CONCEPT: PRINCIPLE OF ACTIVATED SLUDGE

1. Describe the activated sludge process.
2. Define the role microorganisms have in the activated sludge process.
3. Explain the role of activated sludge in the total treatment process.
4. Identify and explain the meaning of the following:

   A. F:M Ratio
   B. MCRT
   C. MLSS
   D. SVI
   E. WAS
   F. RAS

5. Define nitrification and denitrification.

CONCEPT: STRUCTURE AND FUNCTION

6. Diagram and identify the main components of the following modes of operation:

   A. Conventional (Plug Flow)
   B. Step Feed
   C. Contact Stabilization
   D. Complete Mix
   E. Extended Aeration (Oxidation Ditch)

7. List the main controls an operator has over the activated sludge process.

MODULE B: OPERATION AND MAINTENANCE

CONCEPT: OPERATION

8. Explain why the activated sludge process requires a great deal of of operator control.

9. List two purposes for aeration.

10. List the important conditions necessary for the best bacterial growth in aeration basins.

11. Describe the conditions that favor the formation of filaments in the activated sludge process.

12. State the normal range, at the end of the aeration basin, for dissolved oxygen at a plant with a conventional(plug flow) system.

13. List the methods of controlling dissolved oxygen levels in Diffused Air and Mechanical Aeration systems.

14. Explain how an operator can adjust oxygen levels and mixing in an oxidation ditch(extended aeration).

15. Describe the characteristics of normal activated sludge.

16. Describe the characteristics of an anaerobic activated sludge.

17. Describe the characteristics of bulking activated sludge.

18. Describe the characteristics of a rising activated sludge.

19. Explain how solids are generated in an aeration basin, and the consequences if excess solids are not removed.

20. Discuss the characteristics of young and old sludge.

21. Discuss the operational changes necessary if it is determined that a plant has "young" sludge.

22. Discuss the operational changes necessary if it is determined that a plant has "old" sludge.

23. Describe the problems caused by hydraulic overloads in the activated sludge process.

24. State the various control ranges used to determine how much sludge to waste in a conventional (plug flow) activated Sludge plant for the following:

    A. F:M
    B. Sludge Age
    C. Constant MLSS

25. Describe the affect of waste activated sludge concentration on desired wasting rates.

26. List the items to consider in determining sludge return rates.

27. Discuss the affects of temperature on the nitrification and denitrification process.

28. List the methods for preventing denitrification in the secondary clarifier.

CONCEPT: MAINTENANCE

29. List the maintenance considerations for the following:

    A. Centrifugal Blowers
    B. Positive Displacement Blowers
    C. Diffusers

30. Explain why it is important to check for frost obstruction during winter months of blower air intakes, especially with positive displacement blowers.

31. List the items to include in blower maintenance records.

32. List the maintenance considerations for brush and paddle aerators used in oxidation ditches.

33. List two conditions an operator should be aware of prior to emptying an aeration basin.

34. List the items to include in a maintenance inspection of final clarifiers.

35. Describe how to determine if the clarifier weirs are level.

36. List what to look for when inspecting clarifier weirs.

MODULE C: MONITORING AND TROUBLESHOOTING

CONCEPT: MONITORING

37. Explain how to determine the level of magnification of a laboratory microscope.

38. Explain why it is better to start with a low power (5X or 10X objectives) microscope setting before moving to a higher power.

39. Explain the results of too much, or too little, light through a microscope slide sample.

40. Describe how to get a sample and cover slip on a microscope slide.

41. Discuss how to use a mechanical stage on a microscope.

42. Identify the following:

    A. Free Swimming Ciliate
    B. Grazing Ciliate
    C. Single Stalked Ciliate
    D. Community Stalked Ciliate
    E. Sarcodina
    F. Rotifer
    G. Filamentous Organism
    F. Zoo Flagellates

43. Identify the common microorganisms associated with the following conditions:

    A. Young sludge (0-5 days)
    B. Sludge (8 to 10)
    C. Old sludge (20-50 days)

44. Explain the importance of the following equipment in running an activated sludge plant:

    A. A Dissolved Oxygen Meter with Field Probe
    B. A Thousand Milliliter Beaker or Settlometer
    C. A Sludge Blanket Finder
    D. A Microscope

45. Describe the visual observations an operator can make to support laboratory data indicating the following conditions:

    A. Bulking Sludge (Filamentous Bulking)
    B. Too Many Solids in System
    C. Nocadial Filaments Present
    D. Return Rates Too Low
    E. Return Rates Too High

46. List the devices used for measuring the depth of sludge in a secondary clarifier.

47. Identify the sample collection locations for the following tests:

    A. Mixed Liquor Suspended Solids Test
    B. Sludge Settlability Test
    C. Dissolved Oxygen Test
    D. Waste Activated Sludge Concentration Test
    E. Return Activated Sludge Settlability Test

48. Describe and illustrate a simple technique to prevent air bubbles from striking the membrane of a field Dissolved Oxygen Probe.

49. Describe the procedures for determining sludge settlability.

50. Explain the use of dilution in the normal 30-minute mixed liquor settling test.

CONCEPT: TROUBLESHOOTING

51. Discuss corrective actions that can be taken to control filamenteous bulking.

52. Discuss the operational changes necessary when it is determined that an activated sludge plant has rising sludge due to denitrification.

53. Describe the affects of an organic overload, and what corrective actions should be taken.

54. Describe the affects of a toxic discharge, and what corrective actions should be taken.

55. Explain the possible affects on an activated sludge process with the following sidestreams:

    A. Return stream from a thickener that is high in solids
    B. Decanting of an overloaded aerobic digester
    C. Anaerobic digester supernatant high in solids and BOD
    D. Poorly operating mechanical sludge dewatering equipment

56. List three possible causes and corrective actions for low dissolved oxygen in an aeration basin.

57. Identify the options available to an operator of an oxidation ditch that has adequate dissolved oxygen, but is experiencing solids build-up on the basin bottom.

58. Describe the physical and visual observations that would indicate potential problems in the aeration basin related to:

    A. Foam
    B. Color
    C. Odor
    D. Turbulence

MODULE D: SAFETY AND CALCULATIONS

CONCEPT: SAFETY

59. List the safety considerations when storing, handling, and using chemicals.

60. Discuss the hazards associated with both full and empty aeration basins.

CONCEPT: CALCULATIONS

61. Given data, calculate the volume(in gallons) of the following tanks:

    A. Rectangular Tank
    B. Round Tank

62. Given data, calculate percent BOD removal.

63. Given data, calculate the loading (in pounds per day) to an aeration basin.

64. Given data, calculate a sludge volume index (SVI).

65. Given data, calculate the theoretical detention time in a rectangular tank.

66. Given data, calculate sludge age.

67. Given data, calculate an F:M ratio.

68. Given data, calculate for different volumes or concentrations.

ADVANCED

ADVANCED ACTIVATED SLUDGE

MODULE A: PRINCIPLE, STRUCTURE AND FUNCTION

CONCEPT: PRINCIPLE OF ADVANCED ACTIVATED SLUDGE

1. Explain the difference between Mixed Liquor Suspended Solids (MLSS) and Mixed Liquor Volatile Suspended Solids (MLVSS).

2. Define adsorption and absorption as related to the microorganisms in the activated sludge process.

3. Describe where adsorption and absorption in the activated sludge process occurs.

4. Explain why some activated sludge plants must meet ammonia nitrogen limits in addition to secondary treatment.

5. List the conditions which promote the occurrence of nitrification and denitrification.

CONCEPT: STRUCTURE AND FUNCTION

6. List the characteristics of the following activated sludge process modes of operation:

   A. Conventional (Plug Flow)
   B. Contact Stabilization (Two-Tank System)
   C. Step Feed
   D. Complete Mix
   E. Extended Aeration (Oxidation Ditch)

MODULE B: OPERATION AND MAINTENANCE

CONCEPT: OPERATION

7. Outline the start-up procedures for the activated sludge portion of a treatment plant.

8. Discuss when to start wasting sludge when starting-up the following new plants:

   A. A Conventional Activated Sludge Plant
   B. An Extended Aeration Plant

9. List the steps that might be taken to speed-up the formation of sufficient mixed liquor suspended solids when starting an activated sludge plant.

10. List some items to consider before using seed sludge to re-start an activated sludge plant.

11. State the operational F:M range for the following:

    A. Extended Aeration Activated Sludge
    B. Conventional Activated Sludge
    C. High Rate Activated Sludge

12. Outline the visual characteristics of sludge in aeration basins and final clarifiers used to determine sludge age.

13. State the sludge production (in pounds of volatile matter per pound of BOD removed) for the following modes of activated sludge operation:

    A. Extended
    B. Conventional (with Primary Clarification)
    C. High Rate (with Primary Clarification)

14. List three main factors that affect dissolved oxygen demand in aeration basins, and explain how they affect plant operation.

15. List the operational changes that could be made if the dissolved oxygen levels of the inlet end of an aeration basin are too low, while at the outlet end they are too high.

16. Describe how an operator might change the operations of aeration basins to:

    A. Adapt for Extreme Underloading
    B. Change to Step Feed
    C. Change to Contact Stabilization
    D. Change from Contact Stabilization to either Conventional or Extended Aeration

17. Compare the operation of a conventional activated sludge process with the operation of a high purity oxygen activated sludge process.

18. Compare the performance of fine bubble to coarse bubble

diffuser systems.

19. Compare the oxygen requirements for the following modes of activated sludge operation:

    A. Extended Aeration
    B. Conventional
    C. High Rate

20. Describe the considerations that determine the volume of return activated sludge (RAS) to the aeration basin.

21. Discuss the operational problems related to hydraulic overloads from inflow and infiltration, and state what an operator would do to improve plant performance.

22. Explain why excessive inflow and infiltration (clear water) is harmful to the activated sludge process.

23. Describe the strategies for dealing with extreme weekly or seasonal fluctuations in loading rates.

24. Describe when the use of chlorine in return sludge is indicated, and give the recommended dosage in mg/L and pounds per 1000 pounds MLVSS.

25. List the operational modifications an operator of activated sludge systems must make to changeover from summer to winter operations.

26. List the operational costs that would be included in an energy audit of an activated sludge plant.

27. List the potential ways an operator could conserve energy with the following:

    A. Space Heating
    B. Diffusers
    C. Aeration Basin
    D. Flow Equalization
    E. Air Filtration for Compressors

CONCEPT: MAINTENANCE

28. Compare the maintenance requirements of fine bubble to coarse bubble diffuser systems.

29. Discuss how hydrogen chloride gas can be used to clean fine bubble diffusers.

MODULE C: MONITORING AND TROUBLESHOOTING

CONCEPT: MONITORING

30. List the various factors used in evaluating the activated sludge environment.

31. Define Oxygen Uptake Rate (OUR) and Respiration Rate (RR). Show how each is determined.

32. List the conditions that affect the Oxygen Uptake Rate(OUR).

33. Compare Respiration Rate (RR) to Sludge Wasting Rates.

34. State the appropriate carbon, nitrogen, phosphorus and iron ratio.

35. Given the following observations, describe the Sludge Settling Characteristics, Sludge Age and F:M Ratio for a conventional (plug flow) activated sludge plant.

    A. A large variety of organisms with many free swimming ciliates and stalked ciliates; some flagellates and rotifers; and, a few filaments. Good perforate floc

    B. Large numbers of filaments and flagellates; few free swimming ciliates; and, no rotifer or stalked ciliates. Floc is characterized by abundant filaments

    C. Many rotifers; some stalked ciliates; free swimming ciliates; flagellates; and, nematodes. Clotty appearing floc

36. Describe how to control light intensity through a sample being observed by microscope.

37. Explain bench scale testing and how it is used at a treatment plant.

38. Describe how to validate data from permanently installed dissolved oxygen probes.

39. Discuss the uses of the following tests in monitoring activated sludge operations:

    A. Soluble BOD
    B. Chemical Oxygen Demand
    C. Total Organic Carbon
    D. Inhibited BOD

40. Discuss the limitations of using the BOD test results to determine F:M, and describe the possible value of using Total Organic Carbon (TOC) or Chemical Oxygen Demand (COD) tests as a substitute for the BOD test.

CONCEPT: TROUBLESHOOTING

41. Discuss the problems that may occur if a treatment plant experiences partial nitrification.

42. List strategies an operator can use to deal with an industry that:

    A. Discharges Small Amounts of High or Low pH Wastes
    B. Periodically Discharges High BOD Wastes
    C. Discharges Small Amounts of a Toxic Waste

43. Describe what happens in a contact stabilization process if the contact tank is too large for existing flow and loading rates.

44. State the possible causes and corrective actions for the following:

    A. A Sudden Decrease of Dissolved Oxygen in the Aeration Basin
    B. A Sudden Increase of Dissolved Oxygen in the Aeration Basin

45. State the possible causes and corrective actions for the following:

    A. Chronic Low Dissolved Oxygen Levels
    B. Uneven Dissolved Oxygen Levels
    C. Loss of Rotifers While Other Organisms Remain Normal
    D. Loss of Nitrification and Failure to Meet Ammoni Limits

46. State the causes and corrective actions for filamentous growth in activated sludge.

MODULE D: SAFETY AND CALCULATIONS

CONCEPT: SAFETY

47. List various safety considerations that are important in the activated sludge process.

48. Discuss the safety considerations associated with the operation of high purity oxygen activated sludge plants.

CONCEPT: CALCULATIONS

49. Given data, calculate how much sludge to waste per day at a given solids concentration to achieve a desired sludge age.

50. Given data based on chlorine applied per 1000 pounds of MLVSS, calculate the amount of chlorine needed per day.

51. Given data, calculate the following:

    A. Pounds of dry sludge expected for a given sludge generation rate
    B. Liquid gallons to haul at a given solids concentration

52. Given various cost factors, determine the annual cost of disposing of waste activated sludge.

53. Describe ways to determine return rates and wasting rates when there is no means of taking readings directly from a meter.

54. Given data, calculate the daily flow rate of the waste pumps using the change of level in a sludge holding tank.

55. Given data, calculate F:M ratio.

56. Given data, calculate weir overflow rates, surface settling rates, and detention time, for a final clarifier.

57. Given data, calculate the average annual treatment cost for a new industry waste load.

58. Given data, calculate the return activated sludge rate (RAS) and its percentage of influent flow.

59. Given data, calculate the change in volume when a concentration changes.

RESOURCES

1. **ADVANCED WASTE TREATMENT**. 1st Edition (1987), Kenneth D. Kerri. California State University, 6000 J Street, Sacramento, CA 95819-6025. Phone (916) 278-6142.

2. **CONTROLLING WASTEWATER TREATMENT PROCESSES**. (1984). Cortinovis, Dan. Ridgeline Press, 1136 Orchard Road, Lafayette, CA 94549.

3. **OPERATION OF MUNICIPAL WASTEWATER TREATMENT PLANTS**. Manual of Practice No.11 (MOP 11), 2nd Addition (1990), Volumes I, II, and III. Water Environment Federation (Old WPCF), 601 Wythe Street, Alexandria, VA 22314-1994. Phone (800) 666-0206. (MOP 11, 1976 can still be used as a reference.)

4. **OPERATION OF WASTEWATER TREATMENT PLANTS**. 3rd Edition (1990), Volumes 1 and 2, Kenneth D. Kerri, California State University, 6000 J Street, Sacramento, CA 95819-6025. Phone (916) 278-6142.

5. **STANDARD METHODS FOR THE EXAMINATION OF WATER AND WASTEWATER**. 17th Edition (1989), 18th Edition (1992). Joint Publication of: American Public Health Association; American Water Works Association; and, Water Environment Federation (Old WPCF). Publication Office: American Public Health Association, 1015 Fifteenth Street NW, Washington, DC 20005.

7/93